(REFEREED RESEARCH)

EVALUATION OF WEAR IN NEEDLES WORKING WITH OPEN END COTTON YARN

OPEN END PAMUK İPLİĞİ İLE ÇALIŞAN İĞNELERİN AŞINMASININ DEĞERLENDİRİLMESİ

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ABSTRACT

For the knitting process, needles are the main elements and latch needles are used in large quantities in weft knitting machines. Production quality of knitted fabrics is heavily dependent on the longevity and quality of the needles and they are in contact with fibers, yarns and contaminants in the structure of the yarns which results in wear. The purpose of this research is to investigate the problem of accelerated wear on latch needle especially in hook, butt and pivot parts of the latch needle in the case of using 100% cotton open-end yarn. According to the results, the needle fractured from rivet part and there were no fractures at any place of the needle. However, with reference to the SEM views of the needles, there was wear on both needle butt and interior surface of the needle hook. Also, the wear became clear as the number of knitted courses was increased.

Keywords: Latch needle, scanning electron microscopy, open-end yarn, wear, weft knitting

ÖZET

Örme prosesinde, iğneler ana elemanlardır ve dilli iğneler atkılı örme makilerinde sıklıkla kullanılmaktadır. Örme kumaşların üretim kalitesi; aşınmaya neden olan lif, iplik ve iplik içerisindeki kirli malzemeler ile devamlı temas halinde olan örme iğnesinin uzun ömrüne ve kalitesine bağlıdır. Bu çalışmanın amacı, % 100 open end pamuk ipliği ile çalışıldığında örme iğnesinin kanca, pim ve topuk kısmında meydana gelen aşınmanın araştırılmasıdır. Yapılan deneysel çalışma sonucunda, iğne ilk olarak pim kısmından kırılmış ve bu esnada iğnenin başka bir yüzeyinde kırılma meydana gelmemiştir. Fakat çekilen SEM görüntüleri detaylı olarak incelendiğinde, hem iğne topuk yüzende hem de iğne kancasının iç yüzeyinde aşınmanın meydana geldiği görülmüştür ve ortaya çıkan bu aşınmanın miktarının oluşturulan ilmek sayısı arttıkça daha belirgin hale geldiği görülmüştür.

Anahtar Kelimeler: Dilli iğne, elektron mikroskobu, open-end iplik, aşınma, atkılı örme.

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1. INTRODUCTION

During knitting process, needles are the most important stitch formation elements. Any abraded or fracture of these needles cause unwanted and irrecoverable faults on fabric like uneven loop structure, holes and dropped stitches, which cause huge irresistible loss costs. Also reducing the frequency of needle chancing can reduce the cost of new needles as well as extra labor costs. Needle wear mostly occurs at hook tips, latch spoons, throat positions, latch holes and latch rivets of the needles [1-3]. The wear at these parts of the needles is occurred by the help of both knitting variables and yarn properties. Needle timing, dial height, number of feeder, fabric take down tension, input tension, machine speed, carbon-steel content of the needles and chromium content of needles are the main knitting variables which effects the needle wear [2, 4, 5]. Fiber type, yarn type and count as well as twist and contamination, wax level, oxides or silicates on the surface of a spun yarn, matting agent, micro dust level contribute the needle wear [1-6].

Open-end yarns are more abrasive then ring yarns due to the uncontrolled and entangled nature of the fibers that form the open-end yarn structure, fiber particles are more readily deposited on the needle [2-4, 6]. The contribution of wrapper fibers on the surface of open-end yarn hit the needle like speed bumps on a high way and send vibrations through the needle to wear it off [4]. Also yarn contamination as a major contributor to needle wear. Cotton fibers can contain varying degrees of impurity depending on where they are cultivated, the harvesting method, weather conditions and gin treatment (cleaning after harvesting). Some cotton is contaminated by sand dust which is not eliminated by the preparations for spinning and during the spinning process itself, the inevitable result is wear, not only of needles but also yarn carriers, sinkers, cylinders and cams [7]. The position of the abrasive particles in the yarn is of decisive importance in determining the degree of wear. A particle attached to the surface of the yarn clearly exercises the most serious abrasive effect. Yarn manufactures using the open end spinning method tends to demonstrate a greater degree of dust on the yarn surface. The increased number of abrasive particles on the yarn surface of open-end yarn directly relates to the decreased service life of needles [4, 6, 7].

It is the purpose of the study to investigate the mechanism of wear on latch needles with the help of SEM. Scanning electron microscope provides a very large depth of focus which results from the almost parallel paths of the electrons in the primary beam [8]. This facilities the examination of the worn areas of curved metal surfaces, such as the hook, butt and pivot region of latch knitting needles which forms the main subject of this study.

2. MATERIAL AND METHOD

In this study, a set of controlled test productions was carried out. For this purpose, the laboratory type knitting machine, which helps to save material and energy, was employed. The machine was 3.25” in diameter and had 56 needles. During the production process, all the settings were kept constant in order to investigate the lifetime of the needle at standard conditions. The machine had the same equipment such as automatic oil, take up and feeding system, as an industrial one. Before starting the experiment, all of the needles of the machine were replaced with the new ones. The knitting period was ended when a needle breakage occurred. For the study 100% cotton open end yarn was used. The details of the yarn can be seen from the Table 1.

In the beginning of the study the machine velocity was adjusted to 100 rpm, but then increased to 250 rpm and finally the velocity was adjusted to 450 rpm. Table 2 shows how long the machine worked with specified velocities. A positive feeding system was used to supply yarn from side creel to the knitting zone under 4 grams of tension.

Table 1. Yarn properties

Count (Ne)	4/1
Ne CV %	0.01
Twist (turns/m)	400.4
Twist factor (α_e)	5.09
Irregularity (U%)	12.6
Thin Places -50 % (unit/km)	0
Thick Places + 50 % (unit/km)	3.8
Neps + 200 % (unit/km)	381.4

Table 2: Duration and revolution information of machine velocities

Velocity	Revolution	Min
100 rpm	1.935.372	19353,72
250 rpm	7.827.090	31308,36
450 rpm	3.729.780	8288,40

The periodic machine maintenance was also applied such that the needles, sinkers, slots and cams were cleaned in detail. Up to needle fracture, three maintenance processes were made and their details are given in Table 3.

The scanning electron microscope was used because of its good resolution, depth of focus and its ability to provide an understanding of the mechanism of wear and areas of needles affected by wear. SEM images of the needle before and after the knitting processes were also studied in order to compare the surface topology between unused and used needles. The surfaces of the needles from which SEM images were taken as follows:

- Left-right butt
- Butt overhead
- Left-right hook
- Hook (inner part)
- Right pivot

The SEM examination was conducted using a 10-20 kV electron beam and with a magnification range of 10X to 3000X. The images were taken at four different times. By doing this, the advance of wear on needle surface could be visualized. The details when the SEM images were taken can be seen from Table 3. For every maintenance process, four needle samples were taken out for the selected for SEM study and they were replaced with the new ones (see Table 4).

Table 3: Details of machine maintenance periods

	Velocity	Revolution	Total revolution	Min	Total min	Hour	Total hour
1. Maintenance	100 rpm	1.935.372	5.009.201	19353,72	31649,04	322,56	527,48
	250 rpm	3.073.829		12295,32		204,92	
2. Maintenance	250 rpm	1.328.394	6.337.595	5313,58	36962,62	88,56	616,04
3. Maintenance	250 rpm	3.202.257	9.539.852	12809,03	49771,65	213,48	829,53

Table 4. The details of when SEM images were taken

	Total working hour	Total revolutions
Unused needle	0	0
1. Maintenance	527,48	5.009.201
2. Maintenance	616,04	6.337.595
Fracture needle	982,51	13.492.242

3. Results

3.1 Rivet surface

During cyclic loading, localized plastic deformation may occur at the highest stress site. This plastic deformation induces permanent damage to the component and a crack develops. As the component experiences an increasing number of loading cycles, the length of the crack increases. After a certain number of cycles, the crack causes the component to fail [9-10]. In our study, it was the rivet part of the needle where the first fracture occurred after knitting 13.492.242 courses and one of the typical fracture views of the rivet is given in the Figure 1A.

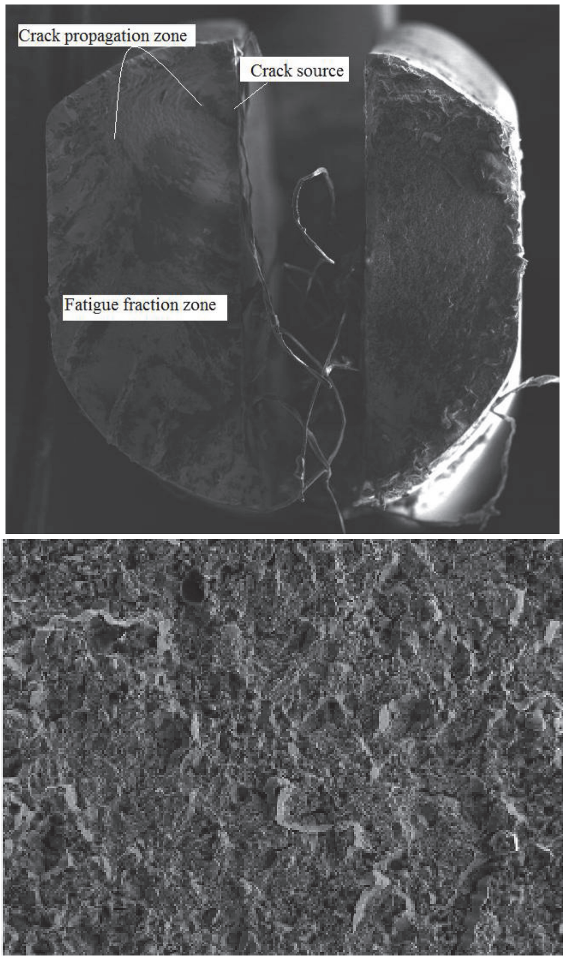
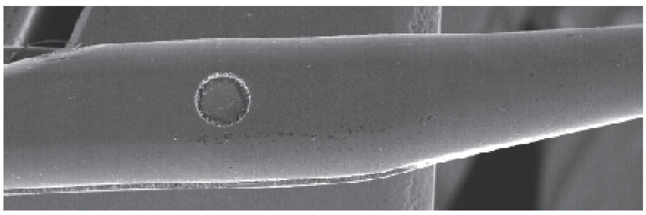


Figure 1. A-10x-Fracture needle rivet cross sectional view 13.492. 242 courses B- 1000x-Enlarge image of dimples

The fracture is composed of three zones: crack source zone, crack propagation zone and fatigue fracture zone. Generally, the fatigue crack is prone to initiate at two kind of specific zones: 1- material surface and 2- inner defect of material [11]. In our study there was only one fatigue source propagating from the surface as shown in Figure 1A. Heterogeneities, micro cracks and mechanical striations were observed when lateral surface of the unused needle rivet part was examined in detail under electron microscope. This could be an additional factor that had given rise to crack initiation as a result of stress concentration. The fracture surfaces of the particles are mostly perpendicular to the uniaxial loading direction, and the cracks propagate from the free boundary to inside, which is corresponding to a maximum principle stress direction. The cracks appear to propagate away from the nucleation site usually in a radial manner (see Figure 1A) [10, 12]. These striations represent the extension of the crack during the loading cycle. When the crack length increases to the critical crack length of the material, the material fractures instantly and meanwhile forms a rough surface since uncracked cross section of the needle could not carry the maximum load of the load cycle anymore. As a result, fracture surface is caused by the final failure in the last load cycle. Therefore, the final failure can be considered to be a quasistatic failure. The fracture zone consists of small quasi-cleavages planes, secondary fatigue cracks and dimples. Greater density of dimples can be observed on the fracture surface of the pivot as shown in Figure 1B.

Figure 2A shows the rivet side view of an unused needle whereas Figure 2B presents the rivet side view of unfractured needle after 13.492.242 courses. From the SEM photos, it appears that wear of the latch hole and rivet had perpendicular visual sight to the latch stem. This finding corresponds with a study conducted by Groz-Beckert which suggested that most of the wear occurs when the needle is in its clearing position and the loop slides off the latch onto the needle shrank. As soon as the latch hole and rivet begins to wear, the loop (when it slides off the latch) is lifting the latch at the fulcrum point thus accelerates the wear of latch hole and rivet [2]. Also, this wear might be the result of abrasive particles in the open-end yarn etching the metal from the surface. As the yarn comes into contact with the throat area of the needle, these fiber particles which contain certain levels of micro dust generate wear on the latch blade and saw slot walls. This condition causes excessive latch play which accelerates wear on the latch spoon and hook tip.



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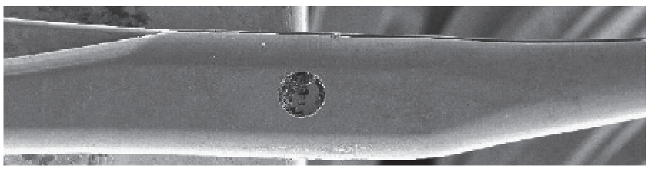

B

Figure 2. A- 10x-Rivet side view 0 courses B-12x-Rivet side view 13.492.242 courses

3.2 Left-right-overhead butt surfaces

From the evaluation of the SEM photos of unused needles, it was observed that two sides of the needle butt had a smooth surface with small original asperities and craters. The surface characteristics of both sides were similar to each other. Also, there was no deformation on the overhead surface of the needle butt. As mentioned in Section 3.1, needle fractured from pivot part and there were no fractures at any place of the needle butt. However, the evaluation of SEM photographs of used needles showed that there was a wear on both upper and bottom parts of the needle butt as seen from Figure 3. The wear mostly occurred in the areas where needle butt follows the cam path. Also, detailed SEM photos of the needle butt demonstrated that the wear at these points grew gradually when the total revolution of the needle was increased. Moreover, the amount of wear on each side of the needle butts was dependent on direction of the machine revolution as the right sides of the needle butts tended to wear more, when compared to the left sides.

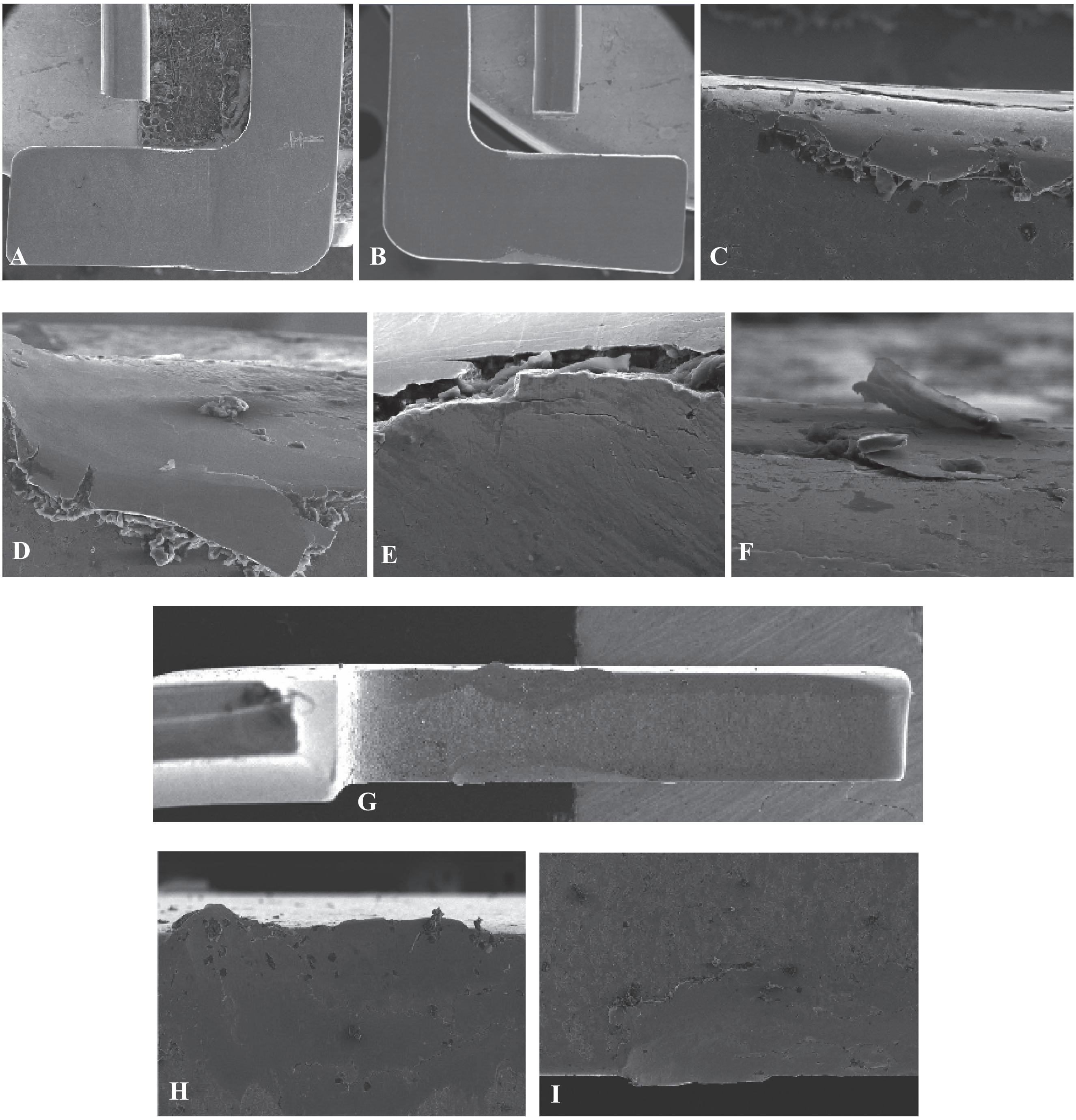

Figure 3. A- 10X- Left side view 13.492.242 courses B-10X-Right side view 13.492.242 courses C- 250X-Left side view 13.492.242 courses D-250 X- Right side view 13.492.242 courses E-1000X- Left side view 13.492.242 courses F-1000x- Right side view 13.492.242 courses G-10 X-Overhead view 13.492.242 courses H-100X-Left overhead view 13.492.242 courses I-100X-Right over head view 13.492.242 courses

The major cause of accelerated needle wear on the needle butt, when using open-end yarns, was the high number of contaminants and small fibers in the yarn which filled into the needle path and slots. Hence, this increased the contact surface and friction between cam and needle which in turn increased the needle wear.

3.3 Left-right-inner hook surfaces

Three unused needles had been examined on the scanning electron microscope (see Figure 4). Two lowest magnifications illustrated that there was some differences in surface features between different unused needles. However, all of them had rough surfaces, defects and cavities at inner contour and two sides of the hook. And, although two sides of the needle hook had different visual view like the different needles surface varied visual characteristics, both sides had similar defects and cavities.

No fracture occurred in hook part of the needle up to pivot breakage for the 13.492.242th course. However, when the surface characteristics were studied from the unused one to pivot breakage, it was found that the wearing off in the hook part moved in more by increasing the number of knitting courses especially at inner contour of the hook. Furthermore, the grooves occurred due to the heavy yarn friction between the yarn and the needle hook became more deepened and extended as the number of knitted courses increased. Figure 5 shows the detectable wear on the inner contour of the hooks at needle breakage time for two different magnification levels. Moreover, abrasive wear was observed on the side of the needle hook as the number of knitted courses was increased. When the needle go through the cam path with a back and forth motion, needle butt creates alternating sign impacts at the moment of the change in the direction of motion which results in collision between latch and hook, hook and thread guide. By doing so, this causes failure of the hook fatigue in nature. In addition to that, uncontrolled and entangled nature of the fibers of the open-end yarn structure played a prominent role in wearing of the hook structure. It is believed that contaminants which are carried out with the yarn from open-end were largely responsible for this increased wear because their relative hardness was higher than the needle itself.

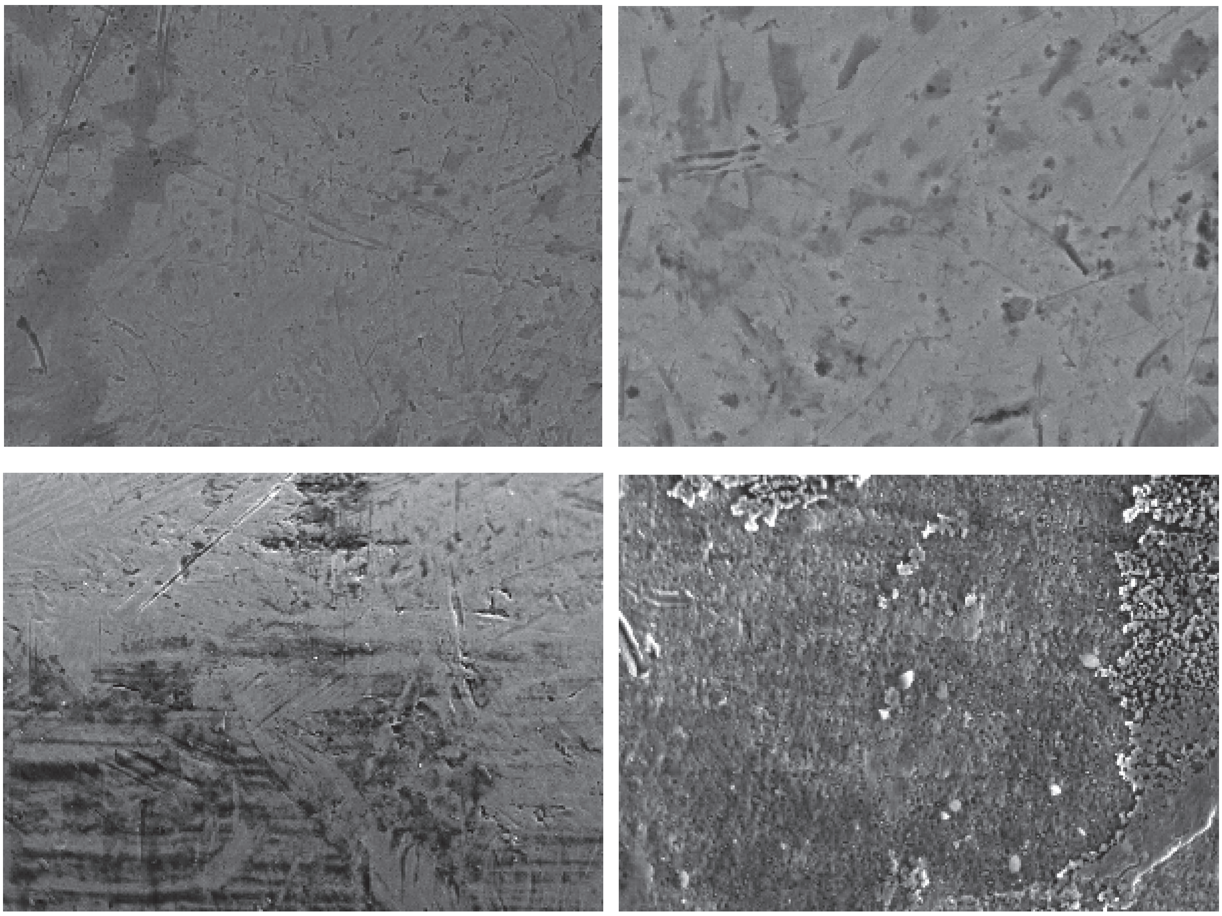

Figure 4. Unused needle hook view A-1000X- Left side view 0 courses B-3000X- Left side view 0 courses C- 3000x- Hook inner contour view 0 course D-3000x- Hook inner contour view 0 courses

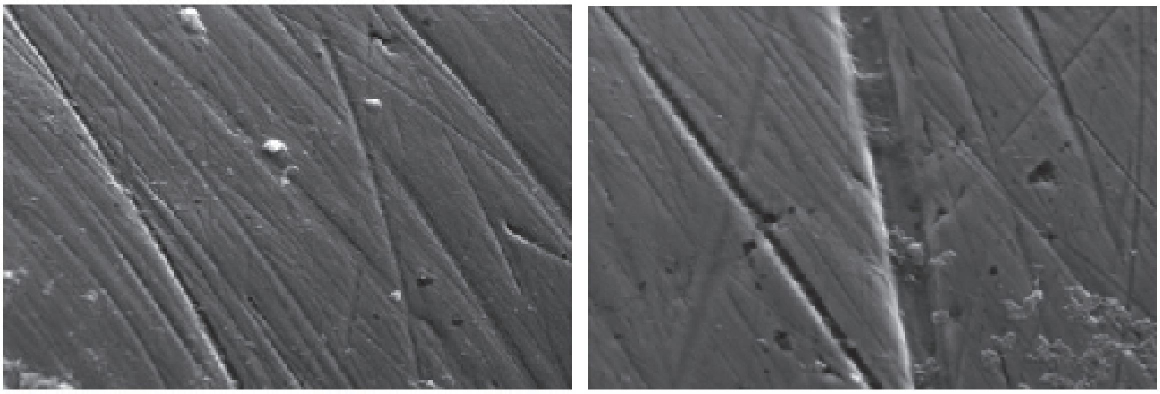

Figure 5: A- 2000x–Hook inner contour view 13.492.242 courses B- 3000x - Hook inner contour view 13.492.242 courses

The comparative study of SEM photos of both groups of needles (used &unused) taken at high magnification, the surfaces of the tops and sides of the grooves were remarkably smooth. Because when two surfaces are in contact, their real area of contact is much less than their apparent area of contact, since it is confined to a number of small areas where opposing high spots touch. Hence, the pressure in these regions was high and the material was overstressed or deformed by the applied load until the contact area was sufficient to support the load. Groove formation cannot be due merely to displacement or removal of asperities. It would seem likely that, in addition to the removal of metal from the surface, there was some plastic deformation of the metal, possibly involving the filling-in of craters [13].

CONCLUSION

In this study, the wear behavior of hook, butt and pivot parts of latch needles were investigated using 100% cotton open end yarn. Scanning electron microscopy (SEM) stereoscopy was used for the evaluation of the surfaces. Unlike the previous studies, the work was conducted such that the knitting process continued until one of the needles on the machine was fractured so that it became possible to see lifetime of the needle. In addition to that, not only the needle hook but also the surface characteristics of the needle pivot and butt were examined in such a way that higher magnifications, together with relatively lower ones, were selected for the SEM study. According to obtained results, it was found that it was the pivot part of the needle where the first fracture occurred because of the fatigue wear after 13.492.242 courses. Due to the impact forces, the adhesive wear increased on the butt of the needle, especially at the contact point with the cam surfaces. Also, as was expected the wear rate increased as the number of knitting cycles raised. The abrasive wear was taken place in the inner contour part of the needle hook at the very beginning of the knitting process. However, the abrasive wear in the surface mentioned above turned into the deep and pronounced grooves and gouges as the knitting process progressed.

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